Current Corn Stover Collection Methods & the Future

The purpose of this talk is to help provide some understanding of the activities that take place in a present day stover harvest. I hope to point out some of the technological barriers that hinder commercialization of corn stover. I will also add some of my thoughts on how we might improve and solve some of the economic, environmental and process issues involved with corn stover.

Gathering Stover

There are several methods we have used to gather the stover into a windrow in preparation for baling. All of the methods have drawbacks; most stem from the fact that the stover was never treated as a valued part of the crop. I will be pointing out some of these problems as I discuss each of the gathering systems.

RAKING

Raking allows for faster drying than does producing a windrow with the combine. The stover is spread over a larger area exposed to sun and wind and then gathered into a windrow after drying. A flail shredder can also increase drying speed by chopping up the stock so that air and sun can be more affective. Some flail shredders can also form the windrow. The amount of material remaining can be controlled to some extent by either raising or lowering of the working edge of the implement. Some root systems containing a fair amount of dirt can be expected to be pulled up by the implements and placed into the windrow. How many root systems are collected is dependent on soil and root conditions for each field and corn hybrid. Once the windrows are created, it is important to get them baled before any rain might occur. If windrows receive more than a sprinkle of rain it may need to be redistributed or allowed a long time to dry. The season will not always allow the extra time needed to dry in the windrow that has been rain soaked.

LEAVING a WINDROW

Leaving a windrow behind the combine can save power and labor that otherwise would be needed for the raking or shredding operations. Size of the windrow will vary depending on the width of the swath taken by the combine, but it is most often smaller than those formed by the rakes and flails. Windrows produced by the combine normally take longer to dry and are at more risk to rain. In most of these situations more stover is left in the field than is needed for adequate ground cover. Also the amount of stover remaining is less uniform across the field. When remaining stover is not uniform across the field, savings in tillage are less likely.

Increasing Density by Baling

The density of the stover in the bulk is around three pounds per cubic foot, so further densification by the baler is necessary with the present harvest and transportation method. No matter which type baling system is used (round or square) density of the stover can be increased to around nine pounds per cubic foot. Dirt and moisture can cause unacceptable down time with either baler type. Baling corn stover is far more problematic than baling hay crops. Properly sized trailers can carry maximum legal loads of either bale type.

ROUND BALES

We have found that a plastic mesh wrap performs better than twine options when producing round bales. The mesh wrap tends to shed water better than twine so less coordination is needed between the baling and hauling operations. Mesh wrap also reduces the amount of tramp stover lost during transport. The cost for the mash wrap is considerable, although much of the cost can be offset by increased production in the baling operation. Cost per ton for baling is generally less (around $15 per dry ton) when using the round baler, primarily because the cost of the baler is about half that of the square baler.

SQUARE BALES

Plastic twine with knot strength of over four hundred pounds is preferred due to the so-called memory of the stover. Both round and square balers take a high degree of expertise to effectively operate when harvesting corn stover. The square baler demands even more expertise than the round baler does. Baling charges for the square bales most often exceed $20 per dry ton. More transportation options and less restrictions are available when transporting the square bales verses round bales. More coordination between baling and hauling operations is desirable with square bales, since their ability to shed rainwater is virtually non- existent.

Transportation

PREPARING STOVER FOR TRANSPORT

When hauling with conventional trucks or non-automated units some amount of staging will be need to take place. Each time a bale is picked up or set down it is a cost, and each additional handling increases the amount of breakage. When using an automated trailer, repeat handling is reduced and staging or preparation for transport is most often not required. The automated trailers tend to save time and money in the field, and can off-load on their own when at the Plant.

RULES OF THE ROAD

Of course there are the normal DOT rules covering length, height, weight, travel after dark and so on. There are also rules that are set by cities and counties concerning mud on roadways, tramp stover and bridge restrictions. Existing infrastructure also creates problems -- it is difficult to turn a seventy-foot transport vehicle into a sixteen-foot field entrance.

MOVING WITH TRUCKS

Taking trucks off road and into the fields for loading can be a challenge in the northern Corn Belt especially in the fall and early winter. Producers will quickly become upset if excess soil compaction is even perceived. Steep field drives; ice, mud and many other factors make it difficult for trucks to operate consistently. Loading bales onto a truck quite often takes more planing than transferring grain from a grain cart onto the semi trailer.

MOVING BALES WITH HIGH TECH TRACTORS

The new high technology tractors can improve field to Plant operations without sacrificing much time on the road. Air ride cabs, air brakes, and special tires allow some of these high tech. farm tractors to travel nearer the speed of normal traffic. The JCB tractors used in our operations are capable of safe road speeds of forty-five miles per hour. Although state laws limit road speeds for this type of farm implement, Iowa has recently increased allowable speeds for implements of husbandry. This type tractor tremendously improves field operations when compared to a conventional truck. Savings are realized for several reasons but some of the biggest reasons include, less handling of the bales and smoother and more consistent field to Plant transportation.

Stover's Arrival at the Collection Point

NECESSARY INFORMATION

Accurate testing of moisture and inert material can be difficult. The typical equipment that might be used to test moistures in hay can be very misleading when testing a bale of corn stover. Representative sampling of the bales is time consuming in comparison with sampling loads of grain.

OFF LOADING

A system of automatically off loading can be important because it is costly to have trucks setting in slow moving lines waiting to be off loaded. In the end, the productivity lost in a line, will cost the manufacturer. In the case of wide loads, such as would be the case with round bales (on conventional trucks), lines can form quickly in the morning since transport of such loads are restricted from thirty minutes after sun up in the morning to thirty minutes before sun down at night. This problem is compounded by the fact that sun light hours are considerably less during the stover harvest season.

Storage and Movement to the Processing Plant

STACKING BALES

Once the bales are off loaded, they are processed or placed on stacks in storage area. Round bales can be placed on stacks with a less experienced operator than is required for square bales. Stacks of round bales also tend to be more stable (in our experience). Round bales that have been stacked, and later moved from storage to processing, will often be somewhat oblong in shape. If travel on a public road is needed to get the bales to processing, transportation will be more difficult and costly. Bale breakage after storage can be substantial and difficult to deal with, often requiring additional labor and equipment.

II. Major Drawbacks with the Present System

Contamination

DIRT AND PLASTIC

The present method of corn harvest does not treat the stover as a valued component of the crop. Rather it is left scattered across the often, muddy field. Every piece of equipment involved in the grain harvest drives over the stover, pushing it into the mud. Dirt contamination is inevitable, often sever enough to cause corn stover to be overlooked as a potential raw material by manufactures. This dirt causes additional problems and extra ware on all equipment involved in the process, including the baler. The dirt builds up on belts or forms chambers, which may lead to rips in the wrap or poorly formed bales. Dirt contamination increases cost of handling and transportation. In the end, it is not a marketable component, but becomes a disposal problem. The dirt causes additional ware and cost in every step including harvest, transport, storage, process and even marketing.

Plastic from the twine or mesh wrap is also often considered a serious contaminate. De-twineing is often a laborious task. Installing equipment that will de-twine or de-wrap adds cost and is not fail proof. Some of the components of corn stover can be sold into markets that can afford relatively high price raw material, these high-value markets often require no plastic contamination at any level. Dirt or plastic contamination can eliminate, or at least aggravate, potential markets.

Deterioration in Storage

CAUSED BY DIRT AND MOISTURE

The more dirt gathered along with the stover when baling, the faster the speed of deterioration. Of course the speed of deterioration is also increased with excessive moisture. Each year the stover harvest window is different. On occasion, a stover harvest with expectable moisture levels will be limited if not imposible. In some years, dry matter losses of bales in storage have averaged as much as twelve percent. Bales containing high moisture and dirt can spontaneously combust. However high moisture or dirty bales, in my opinion, are more likely to exhaust their heat through various cracks in the stack of bales and simply compost. Bales can burn for many reasons, and once ignited, are very difficult to extinguish.

Excessive labor and expertise

Baling operations require an expert in order to maintain a production level that is profitable. These experts can be hard to find while the grain harvest is underway. In fact, many rural areas experience labor shortages during the harvest season. It's also difficult to fully utilize labor during the stover harvest. Many days only allow for a few hours of baling if any, and all of the work hours available are dependent upon the variables of weather. Since the stover harvest is so dependent on frost, dew, clouds and other aspects of weather, labor utilization is similar to that of a fireman. The same problems weather presents in the field occur with trucking and labor in the storage yard as well.

Dealing with Breakage

Producers perceive broken bales in the field as an even larger problem than they actually are. Breakage represents lost profit potential, and burning adds an element of risk. Evenly redistributing the stover can be difficult. If bales are put into storage at the farm site or in the field on a stack, breakage again becomes a source of lost profit to the producer. Transporting the bales after they have been in storage can be more difficult due to deterioration, twine breaks or the changes in the shape of the bales. Dealing with breakage means additional equipment and labor and continues to occur right up to processing.

Consistent Product upon Arrival at Processing
Accommodating differences in bale type (square / round), bale moisture, bale size and breakage have caused problems in maintaining a constant and consistent product flow during processing. Odd shaped or partially broken bales can hang up on feed conveyors. Processing the breakage means dealing with material that is far less dense and makes it difficult to maximize the production rate of the plant. Constant changes in moisture content also results in reduced production since grinding 30% moisture material is quite different than grinding 15% material.

III. B/MAP's Futuristic View

While purchasing corn stover for Great Lakes Chemical Corporation, (whom needed low cost raw materials in order to compete in the world furfural market). I realized that every time we want something it will cost.

For example:

- I want the moisture below 25%,
- I want volume for economics of scale
- I want delivery between 8:00 AM and 5:00 PM,
- I want square 4 x 4 bales only,
- I want a dense bales,
- I want scheduled delivery,
- I want three wraps of plastic mesh,
- I want clean stover.

Realizing that by wanting too much the cost of the raw material could quickly become too expensive. So what is it we really want? I believe the answer is low cost raw material available every processing day with the least amount of contaminates possible. The problem is that the stover harvest tools available today actually create most of the need for the words "I want". Since utilizing corn stover as a feed stock is relatively new and we've not yet invested or installed the infrastructure for harvesting and handling stover, we had better take a futuristic view.

The first thing we should see is that the present system is not treating the stover as a valued component of the corn crop. Presently the stover is strewn about the ground, driven over by all of the equipment involved in the harvest. Under the present system the words "I want clean stover" should not be used. It's not practical to believe that the harvest system can treat the stover in such a manner and still arrive at the plant clean. There are two approaches B/MAP is taking to solve this problem, one is in the short term. We can wash the stover after it arrives at the collection point and hopefully before storage, but at least before processing. The second, more long term approach, includes a harvest method that doesn't tromp the stover into the mud in the first place. We've termed this long-term approach a "Whole Stalk Harvest". The method involves cutting the stalk somewhere below the ear, performing a few simple processes and bringing the whole stalk into the collection point for further processing. Yes, this system will take time to evolve and may not end up exactly as envisioned. It's are opinion Whole Stalk Harvest is an important step in the right direction.

What does the Whole Stalk Harvest method accomplish?

- It can dramatically decrease dirt contamination.
- Eliminate the need for plastic twine and wrap, which is also a serious contaminant.
- Eliminate the cost of the plastic twine or wrap.
- Provide savings with one harvest rather than the present day harvest methods, which includes two harvests (combining of the grain and gathering and baling the stover).
- Open the stover harvest window, by eliminating stovers contact with the ground (which hampers drying).
- Increase the value of the corn crop.

Another project we feel can reduce the cost of stover is to reduce the need for the phrase " I want the moisture content of the stover below 25%". In the Northern Corn Belt, this is a costly thing to want. It not only reduces the harvest window, but in some years can cause a failed harvest, which means no raw material for the Production Plant. That can be more devastating than the deterioration the moisture in a baled storage system might have caused. Again there appear to be two options, one is to dry the stover when necessary before putting it into storage. The second route (I believe to be the best option) is to add water and ensile the stover. We are presently completing some preliminary tests, looking at the effects of ensiling on the stover fiber. B/MAP is also running tests that are looking at several other potential changes in stover characteristics.

What can ensiling the stover accomplish?

- It can increase the harvest window to include more harvest hours in the average day as well as increase the number of harvest days available.
- Reduce or eliminate the risk of fire.
- Cause a consistent and reliable harvest. I use the term "Bankable Harvest".
- Reduce deterioration (dry matter losses) from and expected 12% in bale storage to below 3% in an ensiled bunker.
- Provide characteristics that are more constant when entering the processing plant.
- Enable less costly pre-process handling systems.

Transportation of the corn stover is not only a large cost but can also a logistical nightmare. Especially when large volumes of low-density raw material is required for best economics of scale. The logistical night-mare is further complicated when delivery to the Plant is in bale form, and the integrity of the bales form needs to be maintained into storage and then again into pre-processing. Transporting higher moisture corn stover also can add cost. This brings us to the third futuristic change being researched or considered and quite different from the present methods of hauling and handling corn stover. This system involves a series of smaller collection points perhaps every twenty to thirty miles, connected via pipeline to a large processing complex (Biorefinery). These smaller collection points could better serve the producers in their harvest efforts. This approach would also allow more rural communities the opportunity to more fully participate. These smaller collection points would separate the grain, and possibly the cob, and ensile the remaining stover. When the down stream Biorefinery called for stover, a bunker could be opened and the stover washed into a flume and then into a pumping station where it would be pumped via pipeline to the Biorefinery.

Why a pipeline and not trucks or rail?

- The average moisture of the stover in the new "Bankable Harvest" is expected to be above 30%. The higher the acceptable moisture the wider the harvest window.
- The best moisture to ensile the stover is expected to be between 60% & 70%. So if smaller collection sites were used, a lot of water would need to be transported.
- Pipelines coming into a large Biorefinery from several directions seem to solve a lot of logistical problems. I believe a pipeline potentially could achieve a fairly uninterrupted flow of raw material.
- A pipeline to transport a slurry of corn stover could be installed at a fraction of the cost of a petroleum pipeline and more similar to the cost of a water line.
- Pipelines would overcome any barriers as to manufacture's economics of scale.

Corn Stover Collection Methods - Present and Future

Tom Schechinger
Chairman of the Board of Managers
BioMass Agri Products (B/MAP)*
Harlan, IA
712-744-3296

*Striving to be a cost effective, consistent and reliable supplier of cellulose materials

Corn Stover Collection Methods

Present Gathering:

- Raking
- Leaving a Windrow
- Increasing Density by Baling
  - round bales
  - square bales

Current Stover Bale Transportation

- Preparing Stover for Transport
- Rules of the Road
- Moving with Trucks
- Moving Bales with High Tech Tractors

Stover Arrival at Collection Point

- Necessary Information
  - moisture
  - inert material (dirt)
- Off-loading
  - automatic systems best
  - lines are costly (tempers and $$$)

Storing & Moving at Processing Plant

- Bales are processed or stored
- If stored, must be stacked
- Round bales stack easier and are more stable (but have drawback of getting "out of shape" during storing process)
- Breakage can be substantial

Drawbacks of Present System

- Contamination
- Deterioration in Storage
- Excessive labor and expertise
- Dealing with Breakage
- Consistent Product upon Arrival at Plant

B/MAP's View of the Future

- Tools existing today, actually create a list of expensive "wants":
  - Moisture below 25%
  -Large volume of bales (for economies of scale)
  - "Just in Time" delivery
  - Dense bales
  - Three plastic wraps on each bale
  - Clean stover (treated as valued part of crop)

EACH ONE OF THESE WANTS CREATES ADDITIONAL COSTS

What is it *WE REALLY WANT?*

- A successful bio-refinery needs <u>low cost raw material available every processing day, with as few contaminants as possible.</u>
- Today's tools actually create most of the needs on the "I want" list.
- Since this is a nascent industry, we have the opportunity to create the infrastructure. We need to make sure we create the best infrastructure possible.
- We need to think "outside the box."

Whole Stalk Harvest

What can whole stalk harvest accomplish?

- Decrease dirt contamination
- Eliminate need/cost of plastic twine or wrap (serious contaminant)
- Reduce cost from two harvest system to one harvest system
- Opens harvest window wider
- Increases value of the crop

What else do we REALLY WANT?

- **A stable raw material!**
- Two ways to get "stable" raw material
  - drying
  - ensiling

Advantages of ensiling

- Increases harvest window
- Reduces risk of fire
- “Bankable” harvest
- Reduces deterioration
- Provides raw material with more consistent characteristics
- Less costly pre-process handling systems

What else DO WE REALLY WANT?

- Economical, efficient transportation system
- System that best utilizes cubic feet available on each transportation vehicle
- Would it be possible to have smaller collection sites, and ***PIPE*** the product to the biorefinery?

Why a Biomass PIPELINE?

- Average moisture of the stover at harvest could be above 30% (bankable harvest)
- Stover will be stored at 60-70% (reduces fire risk and deterioration)
- Uninterrupted flow of material (ice, snow, traffic problems, etc. eliminated)
- Pipeline costs would be reasonable
- Economies of scale realized

Bottom line

- Whole stalk harvest saves one harvest cost, which lowers the cost of the raw material
- May also allow for savings in tillage and earnings for carbon sequestration
- We need to explore the possibilities for building the infrastructure for bio-refineries.
- This “exploration” is worthy of taxpayer investment!